RESEARCH HIGHLIGHTS

Technical Series 01-142

ANALYSIS OF THE ANNUAL ENERGY AND WATER CONSUMPTION OF APARTMENT BUILDINGS IN THE CMHC HISTAR DATABASE

Introduction

Apartment buildings represent 31 per cent of the housing stock in Canada and are responsible for 24 per cent of the overall annual energy use within the residential sector. Consequently, research is warranted to characterize the energy and water consumption patterns of this class of buildings, and to identify energy saving measures, greenhouse gas emission reduction potential and cost-saving opportunities to building owners and managers.

In 1999, Canada Mortgage and Housing Corporation (CMHC) commissioned a survey of the building characteristics and energy and water consumption for 40 apartment buildings across Canada. This research provides some insight on the factors that affect the consumption of energy and water in apartment buildings.

In order to better store, manage and analyze this and subsequent survey data, CMHC developed a highrise building statistically representative (HiSTAR) database. Given the limited number of buildings in the database for this first analysis, it is not statistically representative. The results must be interpreted accordingly.

Methodology

CMHC, in cooperation with Natural Resources Canada (NRCan), developed a building characteristics and utility use data collection form for multi-unit residential buildings. The data collected can be used to describe the physical and operational characteristics of the building. The data can also be used to generate input for building energy simulation programs such as DOE 2.1 and NRCan's E.E. 4.

CMHC then contracted with 10 consulting firms to gather data from apartment buildings across the country. Construction dates of the buildings range from 1920 to 1993. The buildings are from six to 26 storeys in height and from 3,345 m^2 to 26,795 m^2 in size, with a total of 27 to 400 suites per building. The buildings are located in the West Coast, Prairie, Central and Atlantic regions of the country. The distribution of buildings in which data was collected was based on the distribution of rental apartment buildings indicated by CMHC's Rental Market Survey. Upon completion of the surveys, CMHC developed a database to store the data and to allow the analysis of energy and water use. The database is known as the CMHC HiSTAR database.

The HiSTAR database is a Microsoft ACCESS program. The data captured for each building include its type, location, construction characteristics, mechanical systems and monthly utility data for a full year. The database contains filters and queries that sort the data according to building age, occupancy (single, seniors, families), ownership (private or social/non-profit), number of storeys, floor area, province, climatic (MNECB) region, number of degree-days, space heating fuel and domestic hot water heating fuel.

HiSTAR can display the relationship between a building characteristic (for example, floor area or number of suites) and energy or water consumption. The program calculates average and standard deviations in energy and water consumption using built-in statistical techniques. Energy consumption is the annual sum of electricity, natural gas, oil, propane and steam usage expressed as equivalent kilowatt hours. Energy use can be normalized by suite, suite/degree-day, floor area, and floor area/degree-day. Similarly, annual water consumption can be normalized by suite and by floor area. The results are displayed in three ways. The program first shows a list of the buildings meeting the filter criteria It then presents average and standard deviations, followed by graphs of the results.

The results of the initial analysis of energy and water use in apartment buildings by the HiSTAR program is discussed in the following section.

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Results

The average annual energy consumption of all 40 buildings was found to be 279 equivalent kilowatt-hours per unit floor area (ekWh/m^2. Average annual water consumption was 2.24 cubic metres of water per unit floor area (m^3/m^2). These results are in agreement with those from other CMHC studies on highrise building energy use[1] and with a recent study of Ontario Housing Corporation apartment buildings[2].

A number of observations emerged from the analysis:

- Apartment buildings built from 1981 to the present consumed 33 per cent less energy per square metre, but about the same amount of energy on a per suite basis, as buildings constructed from 1961 to 1980 (see figure 1). This result is noteworthy because it is usually expected that newer buildings will consume less energy per suite than older buildings. Although the energy consumption per suite is similar for the two groups of buildings, the average area per suite (including common areas) in newer buildings is greater.
- The buildings constructed from 1981 to the present consumed 20 per cent less water per square metre, but 9 per cent more water on a per suite basis than the older buildings (see figure 1).
- Buildings with private ownership (condominiums) used 35 per cent more energy per suite and the same amount of water per suite as buildings with social/non-profit ownership.
- Both energy and water use were found to be similar on a per square meter basis for seniors, singles and families (see figure 2). However, buildings with single persons consumed the least energy per suite: 13,055 ekWh/suite for singles; 23,619 ekWh/suite for families; and 21,231 ekWh/suite for seniors. Usually, it is expected that seniors will consume significantly less energy than families. In this study, seniors' buildings only consumed 10 per cent less energy per suite than family buildings.
- Apartment buildings housing families consumed 44 per cent more water per suite than seniors' buildings. The database provided no information on water consumption for buildings occupied by singles only.

Figure 1. Average annual energy and water consumption according to year built

Year built	Number of buildings	Energy (ekWh)	Energy/Suite (ekWh/suite)	Energy/ Floor area (ekWh/m^2)	Energy/Suite/ Degree-day (ekWh/suite/DD)	Energy/Floor/ area/ Degree-day (ekWh/m^2/DD)	Water (m^3)	Water/ Suite (m^3/suite)	Water/ Floor area (m^3/m^2)
1981 to Present	9	2,553,265	21,437	212	5.89	0.06	21,727	202	2.07
1961 to 1980	26	4,012,513	22,266	317	5.00	0.07	37,624	184	2.59

Figure 2. Average annual energy and water consumption according to occupancy type

Occupancy type	Number of buildings	Energy (ekWh)	Energy/Suite (ekWh/suite)	Energy/ Floor area (ekWh/m^2)	Energy/Suite/ Degree-day (ekWh/suite/DD)	Energy/Floor/ area/ Degree-day (ekWh/m^2/DD)	Water (m^3)	Water/ Suite (m^3/suite)	Water/ Floor area (m^3/m^2)
Singles	2	2,819,148	13,055	221	2.50	0.05			
Seniors	13	2,457,236	21,231	281	4.38	0.06	23,172	149	1.90
Families	2	1,434,574	23,619	163	7.00	0.05	16,188	264	2.24

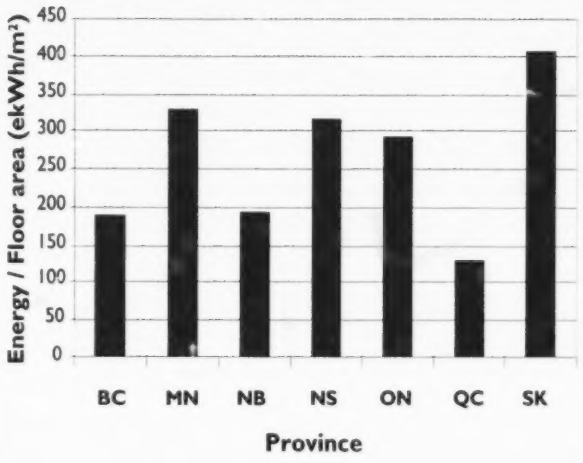
[1] Scanada Consultants, Ltd. *Energy Audits of Highrise Residential Buildings*. Canada Mortgage and Housing Corporation, Ottawa, 1996.

[2] Canada Mortgage and Housing Corporation, Research Highlights. *Review of the OHC Building Energy and Water Audits. Technical Series 00-110.* Canada: CMHC, 2001.

- As shown in figure 3 below, buildings in Quebec, British Columbia and New Brunswick consumed the least amount of energy on a per square metre basis, partly due to the use of electricity as the space heating fuel. Buildings in Saskatchewan had the highest energy usage per square metre.

- Buildings heated by oil or natural gas used about 40 per cent more energy per unit floor area than those heated by hydro-electricity. The higher energy use is attributable to the level of combustion efficiency of oil and gas systems (less than 100 per cent), whereas electric systems are normally 100 per cent efficient at the building level.

Figure 3. Average annual energy consumption/floor area by province



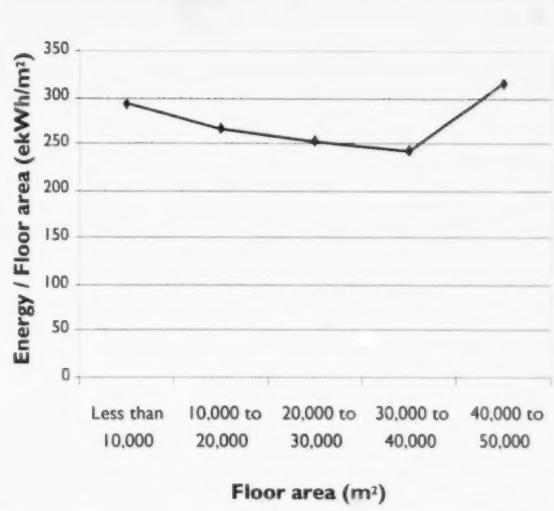
- Buildings using oil or natural gas for domestic hot water heating consumed about 50 per cent more energy per unit floor area in a year than buildings that used hydro-electricity. Here again, the higher energy use is attributable to the fact that the combustion efficiency of oil and gas systems is less than 100 per cent, whereas electric systems are normally 100 per cent efficient at the building level.

- As expected, the average annual consumption of energy per suite and energy per square metre was found to increase as the number of degree-days below 18°C increased. The number of degree-days had no effect on water consumption.

- On average, the buildings in Manitoba consumed the most water per square metre annually, although there was insufficient data to compare water consumption of all buildings.

- With the exception of the largest building in the study, there is a trend to lower energy consumption per square metre as the building floor area increases (figure 4).

Figure 4. Annual energy consumption by floor area



In a study of Ontario Housing Corporation (OHC) apartment buildings, it was found that the energy consumption was 200 ekWh/m²/yr for buildings occupied by seniors, and 232 ekWh/m²/yr for all buildings. The HiSTAR analysis indicates that multi-unit buildings in Ontario occupied by seniors consumed 188 ekWh/m²/yr, and the energy consumption for all social ownership buildings in Ontario was 214 ekWh/m²/yr. The results of these two studies are similar, having only 6 per cent and 8 per cent differences in the findings respectively.

Water consumption for the OHC study apartment buildings was 1.91 m³/m²/yr. Results from the HiSTAR analysis indicate that social owned multi-family buildings in Ontario consumed 1.85 m³/m²/yr of water. The results of these two studies are virtually the same, having only a 3 per cent difference between their average annual water consumption values.

Recommendations

In order to improve the accuracy of analyses afforded by the HiSTAR database, more data should be collected from different regions in Canada. For example, the 40 apartment buildings analyzed in this study include information on only one building in New Brunswick and one in Nova Scotia, and there is no data from Alberta. In order to better understand energy and water consumption trends for apartment buildings in these two provinces, data on more buildings in these provinces are needed. Similarly, it would be beneficial to study more buildings that use oil for space and domestic hot water heating.

Currently, the exact number of apartment buildings in Canada is unknown. Research should be undertaken to determine the population of apartment buildings in terms of defining parameters such as location, age, size and occupancy types. In knowing the actual population of apartment buildings, it will be possible to determine the number of buildings required to make the HiSTAR database truly representative.

Conclusions

This study established an infrastructure for the systematic collection, storage and analysis of energy and water consumption, along with physical and operational characteristics, of multi-unit residential buildings. Trends in energy and water consumption and influencing parameters for these buildings were evident in the limited survey of 40 buildings.

The results indicate that energy and water consumption can vary from building to building. More building files will be required to better define energy and water consumption baselines. The results also show that there are substantial opportunities to improve energy and water efficiency in multi-unit residential building. Recent efforts to construct low energy apartment buildings show that the energy consumption of apartment buildings can be as low as 150 eKwh/m^2.

This project also successfully demonstrated the ability of CMHC's HiSTAR database to serve as a repository for building characteristics and utility data. It successfully demonstrated HiSTAR's capability as an analytical tool for assessing energy and water use in apartment buildings.

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Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

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